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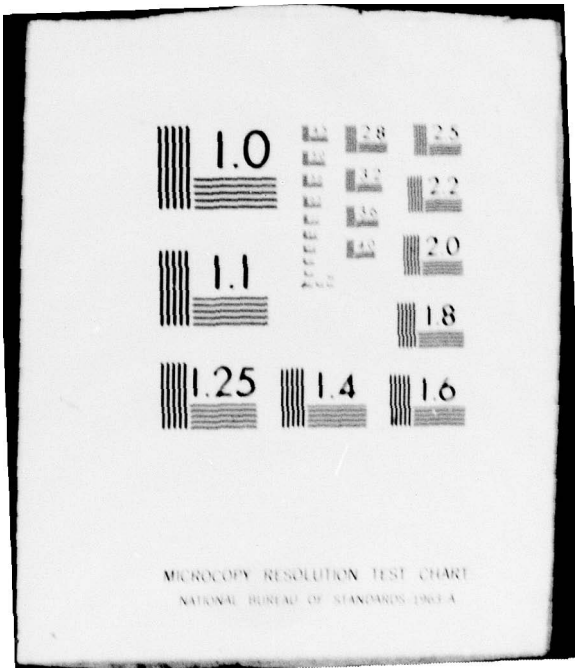
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RESTRICTED
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WOODS HOLE OCEANOGRAPHIC INSTITUTION

Woods Hole, Massachusetts

(1)

(14) WHOI-REF-53-51

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Reference No. 53-51

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(6) NORTH ATLANTIC OCEANOGRAPHY.

under Task Order I

conducted during the period

January 1, 1953 - March 31, 1953

(9) Periodic status rept. no. 27, 1 Jan-31 Mar 53.

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

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Periodic Status Report No. 27
Submitted to Geophysics Branch, Office of Naval Research
Under Contract Nonr-27701 (NR-083-004)

(11) June ~~1953~~ 1953

APPROVED FOR DISTRIBUTION _____
Director

RESTRICTED
SECURITY INFORMATION

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According to the terms of Contract N6onr-27701 (NR-083-004), the work to be performed by the Contractor shall consist of the following:

1. The Contractor shall furnish the necessary personnel and facilities for and, in accordance with any instructions issued by the Scientific Officer or his authorized representative, shall

(a) conduct research, analyze, and compile data and technical information, prepare material for charts, manuals, and reports, and foster the training of military and civilian personnel in the following fields of oceanography;

(i) permanent currents;
(ii) interaction of the sea and atmosphere (including wind waves, swell, and surf);
(iii) the distribution of physical properties;
(iv) the distribution of chemical properties;
(v) the distribution of organisms:
(vi) the characteristics of the sea bottom and beaches;
(vii) tides, tidal currents, and destructive sea waves; and
(viii) the physics and distribution of sea and terrigenous ice.

The research shall include, but not necessarily be limited to, the following:

(1) studies of North Atlantic oceanography;
(2) wave observations and analysis;
(3) current measurements;
(4) studies of Arctic oceanography;
(5) development of unattended instruments;
(6) thermocline studies; and
(7) studies on inshore oceanography.

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SHIP OBSERVATIONS

During this report period field work was limited to a three week period in March, during which the R/V CARYN with Mr. Stommel in charge worked in the vicinity of Bermuda, and a voyage from Woods Hole to Guantanamo by the R/V ATLANTIS. In both cases the costs of operating the vessels were borne by another contract but, in part at least, the observational programs contribute to some of the basic studies reported on here.

The main objective of the CARYN cruise was to study wind currents developing in isothermal water. Three techniques were employed simultaneously: current poles with large metal drags at various depths, the G.E.K., and the bathypitometer. Much of the time it was too rough to use the CARYN effectively. Nevertheless, valuable experience and some insight into the true nature of the observational problem were gained.

A number of successful runs with the current poles were made. In general these showed two or even three currents, one on top of the other. In other words, one possible interpretation is that each time the wind changed a new surface current developed, but the old currents continued to flow for some time beneath. In no case was a simple Ekman spiral to be observed.

Several G.E.K. stations were worked for 12 hours or so. As we have noticed previously the surface water in the Sargasso Sea quite frequently is moving in irregular inertial oscillations. Thus the wind currents are sometimes superimposed on these more or less irregular eddying movements.

From a series of eight hydrographic stations the dynamic topography was found to be extremely flat so that it is certain that there were negligible permanent currents in the area during the period of observation. Tentatively it has been concluded that the irregular fluctuations of the surface current are the result of complicated superposition of inertial oscillations coming in from many different areas of the ocean, which have been subject to winds of different velocities and duration. They certainly do not exhibit the simple rotary form observed in the Baltic Sea.

The local wind currents observed with the current drags appeared to be much shallower than the inertial currents which at times attained a velocity of at least one knot. The very limited amount of data obtained when the inertial currents were weak shows angles between the wind and the surface drift considerably less than the 45° predicted by the Ekman theory. It seems possible that in winter the eddy viscosity is large near the surface due to waves and diminishes rapidly with depth. This might account for the failure of a pronounced spiral to develop.

Having selected March for these observations so that one condition of Ekman's theory would be fulfilled, namely, a deep homogeneous surface layer, it now seems possible that a second condition was usually absent, that is, no change of eddy viscosity with depth.

Because of rough seas and the relatively shallow layer of interest in these attempts to measure wind current, the bathypitometer was ineffective. Dr. Malkus is developing a new design in which the sensing elements will be streamed behind a weight at the end of the supporting cable. In this case there will be no necessity for a considerable catenary to be present in the cable in order to damp out motions of the vessel.

The ATLANTIS' run to Guantanamo produced only routine hydrographic data along tracks that have been often covered. It is interesting to note that during this period the Bermuda high was mostly well south of its usual position so that the CARYN working near Bermuda experienced strong westerly winds and the expected easterly winds off Guantanamo were for a while absent.

NORTH ATLANTIC OCEANOGRAPHY

Average Temperature and Salinity at a Depth of 200 Meters in the North Atlantic. A report on the average temperature and salinity at a depth of 200 meters in the North Atlantic is being written. The temperature and salinity charts have been completed, and charts showing the maximum range of observed temperatures and the anomaly, for each degree of latitude, have been drawn. The base chart used is an azimuthal equal area projection centered at 40°N., 35°W., ranging from 6°S. to 86°N. and 45°E. to 105°W., prepared by M. J. Pollak and G. G. Pasley. The new charts cover several areas not included in the METEOR Atlas. A total of 40,000 temperature observations and 14,000 salinity observations were used in computing these charts.

Second Trade-Wind Cruise. The routine processing of data from ATLANTIS Cruise 181 was completed during the quarter. These data proved to be an important part of the material used in producing the 200-meter charts mentioned above.

The Effect of Surface Wind on the Yearly Brood Strength of Georges Bank Haddock. Mr. Chase has shown that the yearly brood strength of haddock is largely dependent on what happens during the pelagic stage when the eggs and larvae lie suspended in the upper ten meters of water. Wind-driven currents were found to play a large role in the movement of these eggs and larvae and consequently in the location of the larvae at the end of the four

month pelagic stage. At the end of the pelagic stage the larvae sound to the bottom and their survival there as fish depends on the bottom being at a depth of 50 fathoms or less.

The British have recently developed a good correlation between yearly brood strength of North Sea haddock and mean wind during the pelagic season. The U. S. Fish and Wildlife Service attempted a similar correlation for Georges Bank haddock but failed to get good results.

In cooperation with the Fish and Wildlife Service, work was begun during the quarter by Mr. Chase on correlating wind over shorter periods to the yearly brood strength of Georges Bank haddock. The short-period regimes of northwesterly winds were felt to be more useful to the study than seasonal average winds because of the existence of an easterly current off the shelf some 40 miles from Georges Bank. It appeared reasonable, for example, to believe that any eggs or larvae which might be borne by wind-induced currents to the region of the easterly current would then be carried eastward and hence lost to Georges Bank regardless of any later regime of southeasterly winds.

To get a measure of the component of wind-induced current at right angles to the shelf, a plot was made of the pressure difference between Nantucket, Massachusetts, and Yarmouth, Nova Scotia, at 1230Z each day during the normal pelagic season from the 17th of February through the 15th of June for the years 1928 through 1939 and 1944 through 1948. If we assume (1) that the surface wind blows in a direction 20° counterclockwise from the geostrophic wind and (2) that the wind-induced current flows in a direction 45° clockwise from the surface wind, then the water flow is 25° clockwise from the geostrophic flow. The angle between the Nantucket-Yarmouth line and the line of the southern edge of Georges Banks is about 25° in a clockwise direction so that if the assumptions (1) and (2) above are valid, the Nantucket-Yarmouth pressure difference is proportional to the component of water flow at right angles to the southern edge of the Bank.

The plots of the Nantucket-Yarmouth pressure difference were examined for all periods where the difference was +5 mb. or more and +10 mb. or more. The choice of 5 and 10 mb. was somewhat arbitrary but consideration was made of the distance from the edge of the Bank to the eastbound current and of an assumed water speed of about 3-1/2% of the surface wind speed. "Damage Units" were then assessed for each period of offshore winds according to the following tables:

No. of days when pressure difference was continuously	Damage Units for the period
5 mb. or more	
1	1
2	2
3	4
4	7
5	10
6	13
7	16
10 mb. or more	
1	1
2	3
3	5

A correlogram was made of the yearly brood strength vs. the seasonal total of damage units for the period 17th of February through the 30th of April (Fig. 1). The damage during the latter part of the pelagic season, i.e., 1 May through 15 June, was found to be very small and was not considered. As can be seen from the correlogram, the points for all of the years except three lie within 5 units of a straight line.

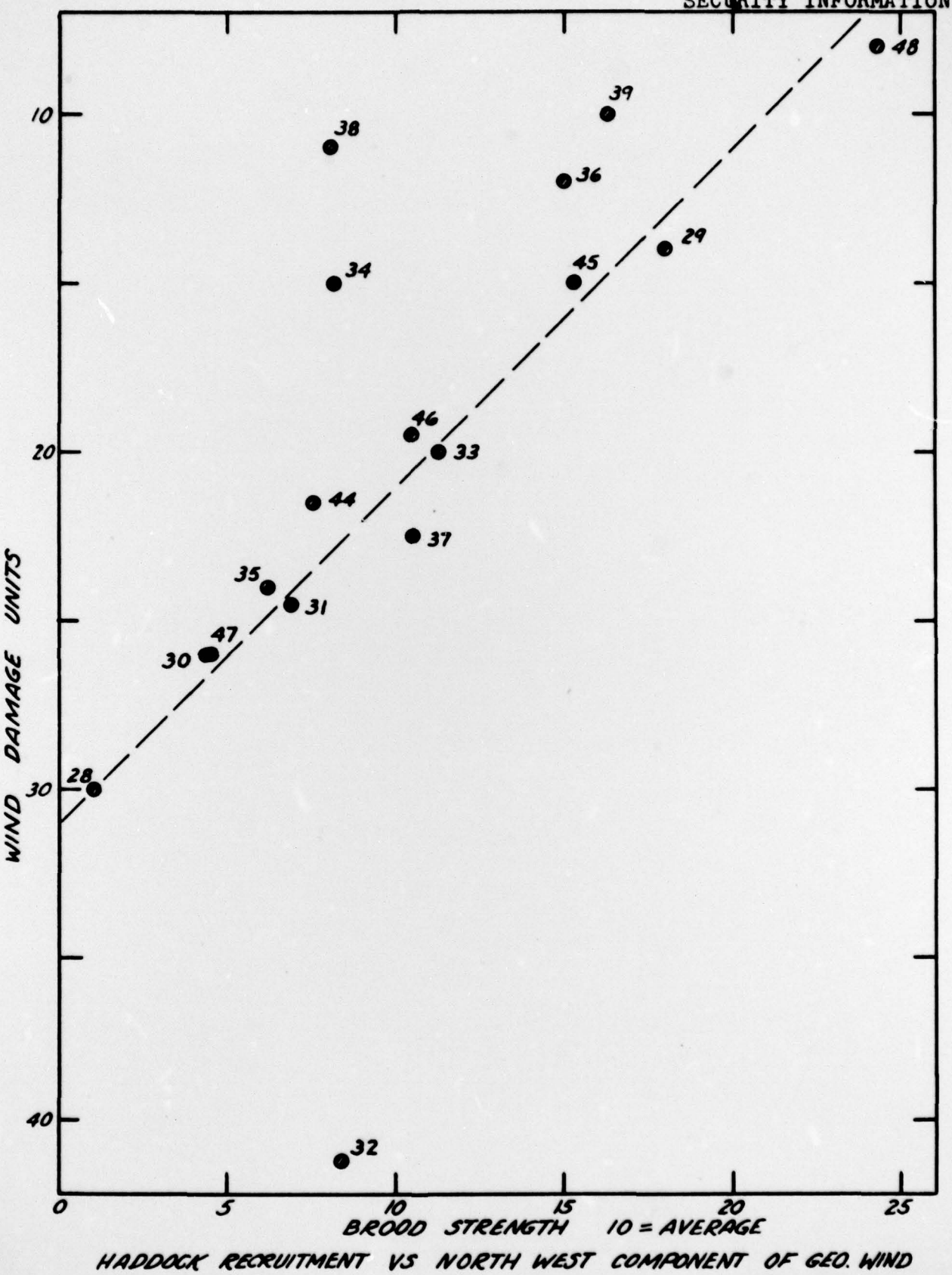
Apparently some other variables besides wind must have affected the strength of the year classes of 1932, 1934, and 1938. There is evidence that the egg laying season does not always start near the middle of February. Preliminary reports from a recent cruise indicate a delay of a month in egg laying this year. Such a variation could have considerable effect on the correlogram of Figure 1.

The work is being continued with a study of winter temperatures to see if a clue to the date of egg laying can be found.

File of Historical Weather Maps. The following maps have been added to the file during this quarter:

U.S.W.B. (La Guardia) North Atlantic weather charts for January, February, and March 1953.

U.S.W.B. Historical Weather Maps for the Northern Hemisphere for January through December 1950 and for January through May and for September of 1951.



HADDOCK RECRUITMENT VS NORTH WEST COMPONENT OF GEO. WIND

FIG. 1

U.S.A.F. Historical Weather Maps, Northern Hemisphere for October and December 1945; October, November, and December 1946 and for January through September 1947.

Appearance of the Sea Surface from the Air. A further study of the surface outcrop of the Gulf Stream front was made from Navy PBY-6A during 26-27 February 1953 by Mr. von Arx and Dr. Richardson. The experience obtained during the earlier flight made in November proved of value in maintaining contact with the frontal outcrop throughout the distance from Miami, Florida, to the 70°W. meridian. It was found that the surface outcrop of the Gulf Stream front was discontinuous at intervals in the order of 300 km. in the region over the Blake Plateau and that the discontinuities were more frequent where the Gulf Stream enters deeper water east of Cape Hatteras. In every case where the visual and thermal indications of the frontal edge became obscure, contact was resumed on the left, facing downstream. The same visual and instrumental techniques were used on this flight as on the previous one.

Further development of both the airborne radiation thermometer and wide-field time-lapse photographic camera is in progress. A technical report on the results of the February flight bears WHOI Reference No. 53-24. A description of the wide-field time-lapse technique has appeared both as a technical report (WHOI Ref. No. 53-9) and as a manuscript for publication in the Journal of the Society of Photographic Engineers, now in press.

Key West Gulf Stream Measurements. The variations in electrical potential developed across the Strait of Florida were measured on a regular schedule calling for 60 hours of continuous recording on week-ends.

The recording equipment is in charge of Mr. Moore of the Western Union Telegraph Co.

Analysis of the data obtained since last August is now in progress.

DEVELOPMENT OF INSTRUMENTS

Unattended Instruments. A period of two weeks was spent in Bermuda to study potentialities of the phase-difference radio-ranging technique under consideration for use with unattended free-floating telemetering buoys. In these experiments the island station on Bermuda was equipped with radio transmission and receiving apparatus similar to that which would be supplied an oceanographic vessel. The R/V CARYN was equipped with the radio

receiving and transmitting equipment under consideration for use in buoys. The Bermuda station was also equipped with direction finding apparatus. Four experiments to a range of 60 miles show that a phase-difference method can give usefully reliable indications of the range of buoys, but that the radio frequencies employed (2 to 3 mc.) are generally too high for accurate direction finding. When appropriate adjustments were made of the circuits aboard the CARYN it was possible to interrogate the CARYN from Bermuda and obtain an automatic response. Further work at lower radio frequencies is clearly desirable, but raises the problem of the design of suitably long antennas or their electrical equivalent.

Recovery Program. Work during this quarter proceeded on the development of a device for the recovery of instruments from the deep ocean after long periods of time, the testing of various components of such a device, and the construction of two explosion-actuated releases for use in deep water.

The release in its present configuration is designed to be dropped freely to the bottom from a vessel for later recovery. Having reached the bottom it emits an acoustic signal, a tapping audible for several miles, to aid in relocation. The power supply for the tapper is sufficient for about 100 days of operation. The explosion of a 50 lb. TNT charge at a distance of about one mile releases the anchor, allowing the instrument to float to the surface for recovery.

A cable lowered model of the release was constructed and tested in order to determine its sensitivity to distant explosions. Unfortunately, this device was lost in Vineyard Sound, but not before it proved to have at least its intended sensitivity, so no attempt was made to recover it or rebuild it. On the basis of this test and a test of the tapper or signaling device, two units were constructed to be tested in the deep water off Bermuda early in April.

If the Bermuda tests are successful, certain obvious improvements will be made to make the device physically smaller. The sensitive element of the release is essentially a diaphragm-actuated switch which closes momentarily on the passage of an explosive shock wave of about 3 psi peak pressure. The greater part of the volume of the device is chargeable to the tank of compressible fluid (sea water) backing up the diaphragm, and the greater part of its weight is chargeable to the tapper and pressure case. The two experimental devices were very conservatively designed, and it is expected that the tests will indicate the possibility of a considerable reduction in size and weight, and that integral flotation can be provided.

MODEL STUDIES OF OCEANS

Experimental work with the rotating basin was suspended during this quarter in order to make further theoretical studies in preparation for new experiments and to consolidate the work already done. Most of the latter has been published by Mr. von Arx under the title "A Laboratory Study of the Wind-Driven Ocean Circulation", which appeared in Volume 4, No. 4, of Tellus, November 1952.

A matter of some interest in these results is the pulsation of the flow through the Straits of Florida and the propagation of these pulses downstream as far as the Norwegian Sea. It is not known at the moment whether these pulsations are due to experimental difficulties or represent a parallel process in nature. The electromagnetic evidence being obtained between Key West and Havana suggests a pulsation of the flow in the Straits of Florida related to the tide in the Gulf of Mexico. Pillsbury's observations (1889) in the Straits of Florida and near Cape Hatteras suggest tidal modulation of the current velocity, and Parr's observations (1937) show similar effects apparently related to the semidiurnal tide.

The tide in the Gulf of Mexico undergoes a biweekly change from predominantly diurnal oscillations to predominantly semidiurnal oscillations. The semidiurnal species require little or no change in the total volume of water in the Gulf since the nodal line or its equivalent seems to correspond roughly with the 90°W. meridian. These oscillations appear to be in phase with the arrival of the semidiurnal oscillations in the North Atlantic basin and expressed in the Straits of Florida as a progressive wave. The diurnal tides, however, are essentially in phase at all points around the perimeter of the Gulf of Mexico and require that each rise and fall of the diurnal tide be accompanied by a change in the volume of water in the Gulf equal to a tidal prism of height approximately 40 cm. It appears from Parr's observations that the flow through the Yucatan Channel during eight hours is sufficient to supply this volume during the rise of diurnal tide in the Gulf of Mexico. One is led to suspect therefore that the flow of water through the Straits of Florida may be modulated by the diurnal tide in the Gulf by a factor of 2 during the period of predominantly diurnal tides and that the flow may remain more nearly average during the period of semidiurnal tides. Field studies are being planned with this working hypothesis in mind.

ARCTIC OCEANOGRAPHY

Arctic Field Observations. On 15 January 1953, Mr. Worthington returned from the ice island, T-3. Mr. Holmes and Mr. Worthington

have completed a report on Project Skijump II (WHOI Ref. No. 53-23) which was submitted in April.

A technical report on the oceanographic work performed on ice island T-3 is nearing completion. It is being held up pending the arrival of salinity samples from the ice island.

On the 23rd of March, Mr. Metcalf returned from a six months leave of absence and resumed his work on oceanographic data collected during the 1951 and 1952 winter cruises to the Norwegian Sea.

Relations between North Atlantic and Arctic Weather. The objective of Mr. Schell's research during the past quarter was to study the relation between the northern North Atlantic ocean surface temperature trend and the corresponding sea ice trend and the degree of relation of the air temperature over Iceland to the sea surface temperature in that vicinity. An estimate of the severity of the 1953 iceberg season off Newfoundland was also made.

1. The ocean surface temperatures for 16 areas in the northern North Atlantic, north of 50°N. extending from off Newfoundland to the British Isles and covering the period 1881-1950 (not including the war years), were averaged by decade or by shorter periods for each area and for the area as a whole. The values of temperature change from decade to decade were then compared with the character of the ice off Iceland during 1881-1950 and with the average ice limit in the area, Cape Farewell east to Novaya Zemlya during 1901-39, 1946-49. It was found that an increase in temperature for the area as a whole from one decade to the next occurred with either a decrease in the ice from the preceding decade or when a decade with very little ice followed another with also very little ice off Iceland. On the other hand, the decades with decreasing ocean temperatures from the decade before were accompanied as a rule by increases in the severity of the ice off Iceland.

Similarly, a decade with an increase in temperature from the preceding decade was associated with a northward retreat of the ice limit in the area as a whole and a decade or shorter period with a decrease in the ocean temperature was associated with a southward advance of the ice limit.

2. The mean annual sea surface temperature at Stykkisholm on the west coast of Iceland was correlated with mean annual and four seasonal air temperatures for the same station. A marked degree of correlation was found between the sea and the air temperatures, yet one which would explain only half of the variations of either temperature in terms of the other. This suggests that to a considerable degree, the air and sea temperatures off the west coast of Iceland are also independent of each other.

3. The mean December 1953 to March 1953 pressure difference between Belle Isle and Ivigtut (Greenland) together with the mean Newfoundland air temperature (St. Johns) for the same four months were employed in the formula for deriving the departure from the long-term average in the iceberg count off Newfoundland (south of Latitude 48°N.). The obtained departure on a scale of 10 is -0.8 and suggests another below normal season for this year, the third in a row.

This indication for a lighter than usual berg count is not as marked, however, as in 1951 and 1952 when the computed departure was greater than unity, -2.2 and -1.4, respectively.

Future Plans. It is planned to extend the investigation of the role of sea surface temperatures in the circulation by correlating their values with the corresponding values of pressure, precipitation, and storminess.

THERMOCLINE STUDIES

Mr. Martineau carried out a study of objective methods of predicting the so-called afternoon effect. Working with bathythermograph data from 24 cruises in mid-latitudes of the North Atlantic he developed a set of rules for forecasting Slight ($\leq$ .2°F.), Moderate (.2°F. to .6°F.) and Intense ($>$ .6°F.) diurnal warming. The factors used were wind force, the difference in temperature between the air and the water, the altitude of the sun, and a combined measure of the sea and cloud conditions.

Unfortunately, the quantity of suitable data on file is inadequate for a thorough test of his method, especially outside of mid-latitudes. What is needed are several long runs when the observing vessel remains in the same body of water. However, the results seem sufficiently promising so that further effort is justified.

Mr. Martineau's studies have been summarized in WHOI Reference No. 53-21.

MISCELLANEOUS

Salinity Titrations. The following groups of salinity samples have been titrated:

USS EDISTO	360
USS ATKA	160
Great South Bay	76
Ice Island T-3	65
ATLANTIS, Cruises #180, 181	840
Repeats on ATLANTIS, Cruise #178	55
Miscellaneous	35
Total	1,591

One U. S. Coast Guard member of Mr. Soule's group was trained for a period of two weeks.

Alvin L. Bradshaw, Ralph F. Wyrick, and James E. Hanks of WHOI were trained for one day each in preparation for the ATLANTIS cruise.

Materials were gathered, solutions prepared, and substandard water bottled for the laboratory setup on the ATLANTIS.

All available samples were completed.

The above work was performed largely by two people under the supervision of Mr. Bumpus.

Thermometer Calibrations. During the first quarter of 1953, 37 reversing thermometers were calibrated for the U. S. Coast Guard, 15 for the University of Miami, and 10 for the U. S. Fish and Wildlife Service. This amounted to 62 ice points, 28 V_0 determinations, 305 points on the temperature scale from 2.°C. to 50.°C., and some 24 pressure factor determinations.

Some of this work, for the U. S. Coast Guard and the U. S. Fish and Wildlife Service, was for acceptance of new thermometers under the specifications applicable to their respective contracts with the manufacturers. The majority of thermometers yet to be tested for acceptance had not been delivered for test up to the end of the first quarter.

This work has been carried out by Mr. Whitney, Jr., under the supervision of Mr. Bumpus.

BIBLIOGRAPHY

Papers Submitted for Publication. The following papers were submitted for publication:

Ketchum, B. H.: Circulation in estuaries. Council on Wave Res.

Stommel, Henry: Computation of pollution in a vertically mixed estuary. Sewage and Industrial Waste.

Stommel, Henry: Examples of the possible role of inertia and stratification in the dynamics of the Gulf Stream. J. Mar. Res.

Published Papers. The following papers were published during the quarter:

Ford, W. L., and A. R. Miller, 1952: The surface layer of the Gulf Stream and adjacent waters. J. Mar. Res., 11(3):267-280, 7 text figs.

Redfield, A. C., 1951: The flushing of harbors and other hydrodynamic problems in coastal waters. Hydrodynamics in Modern Technology, Mass. Inst. Tech., Dec. 1951 : 127-135.

Technical Reports. The following technical reports were distributed during the quarter:

Reference No. 53-9. Ultra-wide-field Time-lapse Photography from Aircraft. By William S. von Arx. February 1953.

Reference No. 53-21. An Objective Method for Forecasting the Diurnal Thermocline. By Donald P. Martineau. March 1953.

PERSONNEL

The following personnel were engaged in either full- or part-time activity under this contract. Not included in this list but contributing to the work were shop workers, maintenance personnel, crews of vessels, and the administrative staff of the Business Office.

Assignment	Name	Title
DIRECTION AND ADMINISTRATION	Ed. H. Smith	Director
	C. O'D. Iselin	Sr. Physical Oceanographer
	A. C. Redfield	Associate Director
	R. A. Veeder	Assist. to the Director
	Jeanne M. Backus	Secretary
HYDROGRAPHIC OBSERVATIONS AND ANALYSES	Nellie Andersen	Senior Technician
	D. F. Bumpus	Oceanographer
	J. Chase	Res. Assoc. in Oceanography
	H. G. Farmer, Jr.	Res. Assoc. in Engineering
	D. H. Frantz, Jr.	Res. Assoc. in Engineering
	F. C. Fuglister	Oceanographer
	W. V. R. Malkus	Physicist
	Donald P. Martineau	Res. Assoc. in Oceanography
	W. G. Metcalf	Res. Assist. in Oceanography
	I. I. Schell	Meteorologist
	H. M. Stommel	Oceanographer
	L. A. Thayer	Research Engineer
	Evangeline Tollios	Senior Technician
	L. V. Worthington	Res. Assoc. in Oceanography
PHOTOGRAPHY, DRAFTING AND TITRATING	F. A. Bailey	Draftsman
	Gloria Gallagher	Multilith Operator
	W. T. Hammond	Res. Assist. in Oceanography
	Mary Manning	Technical Assistant
	Dona Nelson	Technical Assistant
	D. M. Owen	Res. Assist. in Oceanography
	F. C. Ronne	Photographer
	J. W. Stimpson	Draftsman
	Phyllis Vail	Technical Assistant
	G. G. Whitney, Jr.	Res. Assist. in Engineering

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